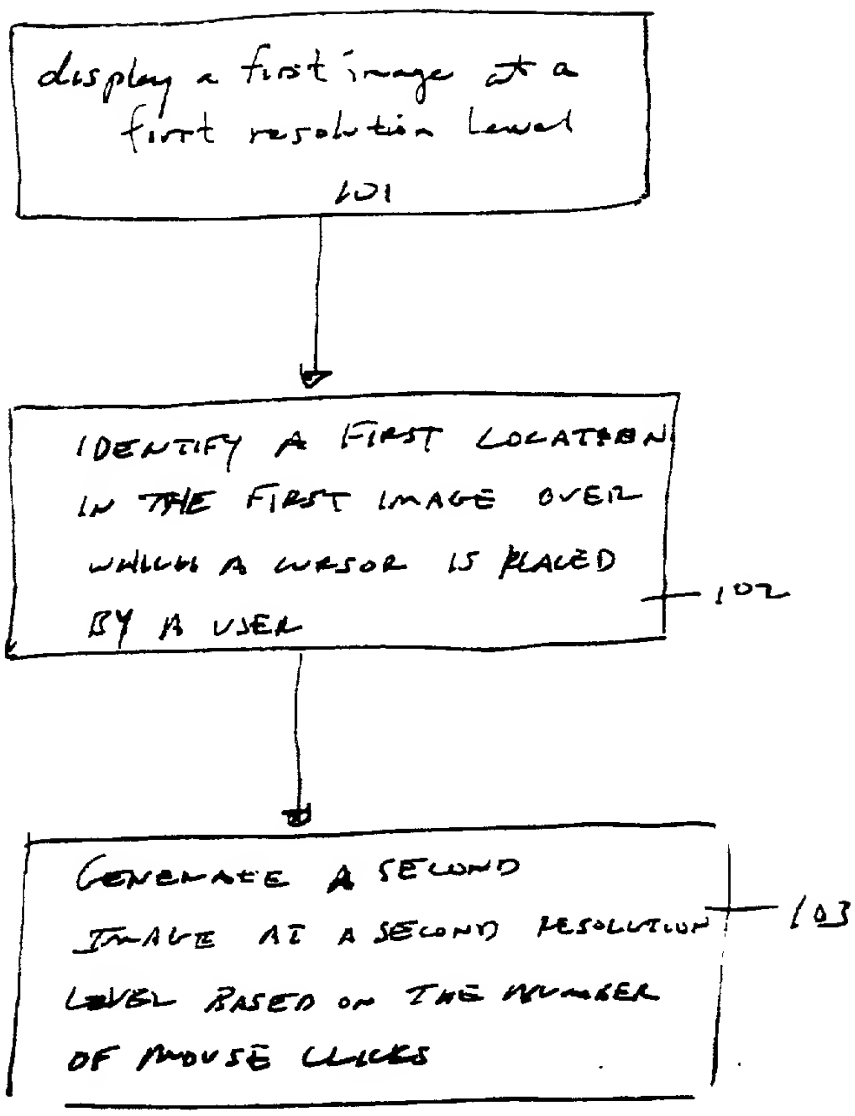

display a first image at a first resolution Level
101
IDENTIFY A FIRST LOCATION IN THE FIRST IMAGE OVER WHICH A CURSOR IS PLACED BY A USER
102
GENERATE A SECOND IMAGE AT A SECOND RESOLUTION LEVEL BASED ON THE NUMBER OF MOUSE CLICKS
103

Figure 1

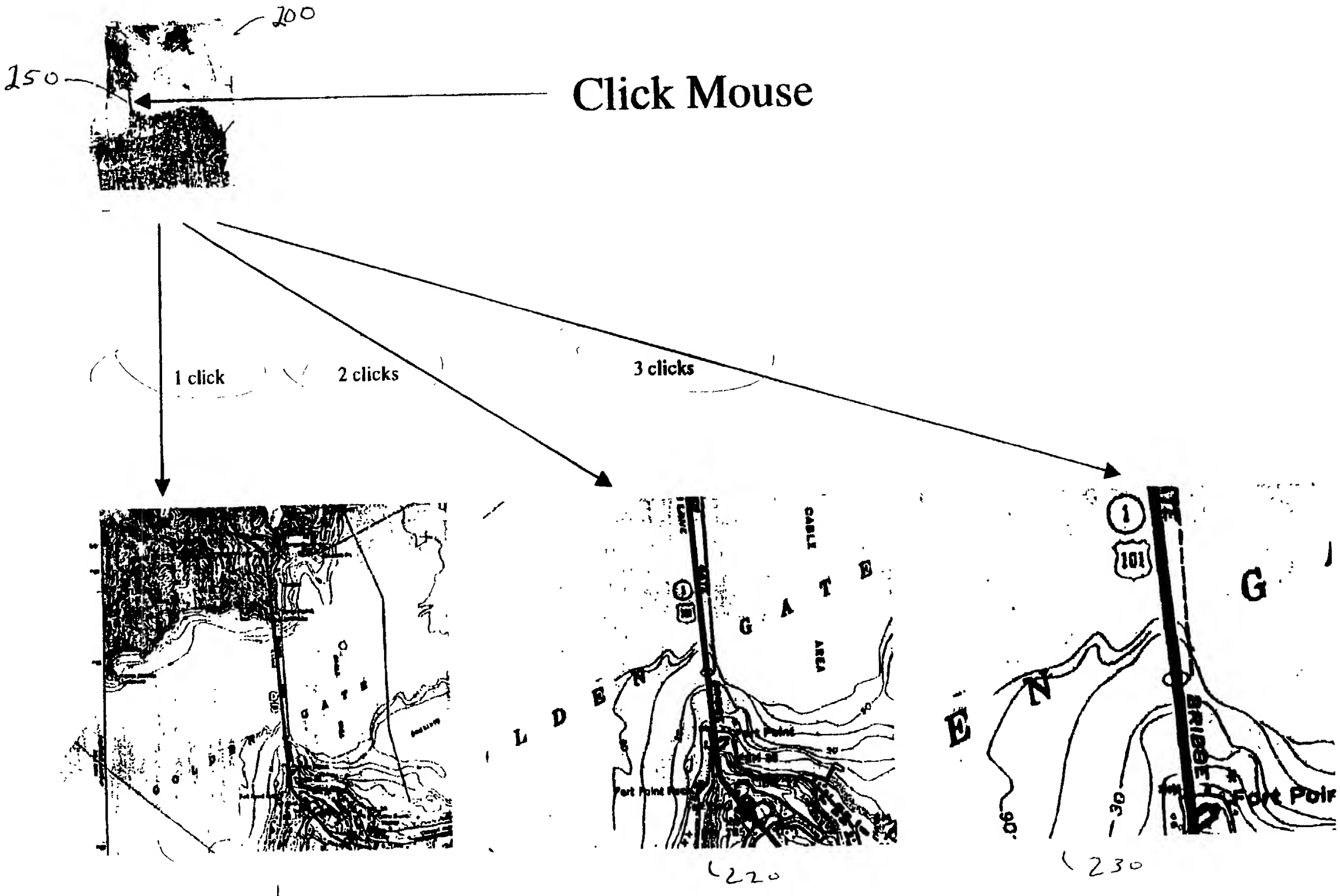
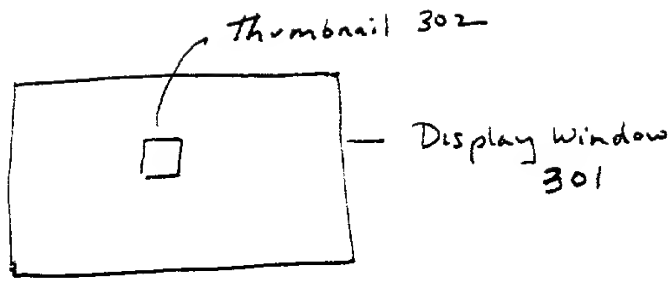

200
150
Click Mouse
1 click
2 clicks
3 clicks
GOLDEN GATE
GOLDEN GATE AREA
101
BRIDGE
Fort Point
Fort Point Pier
-30
-60
210
220
230

Figure 2

Figure 3A



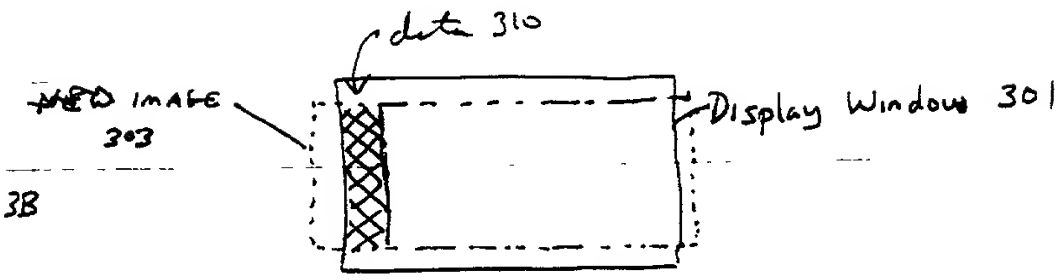


Figure 3B

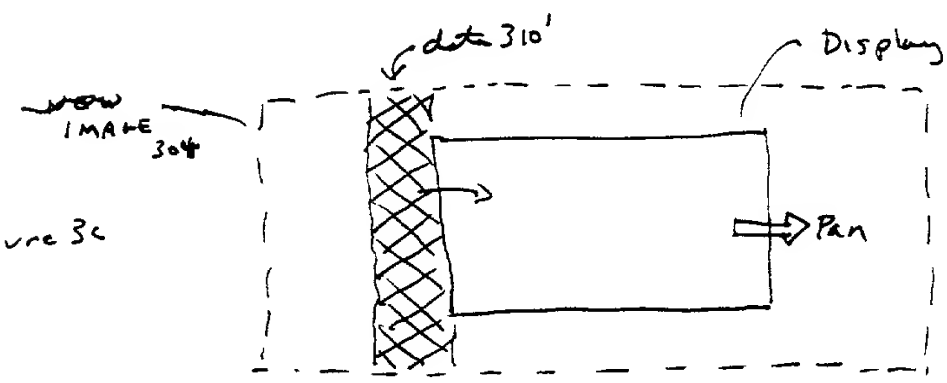


Figure 3C

Figure 3

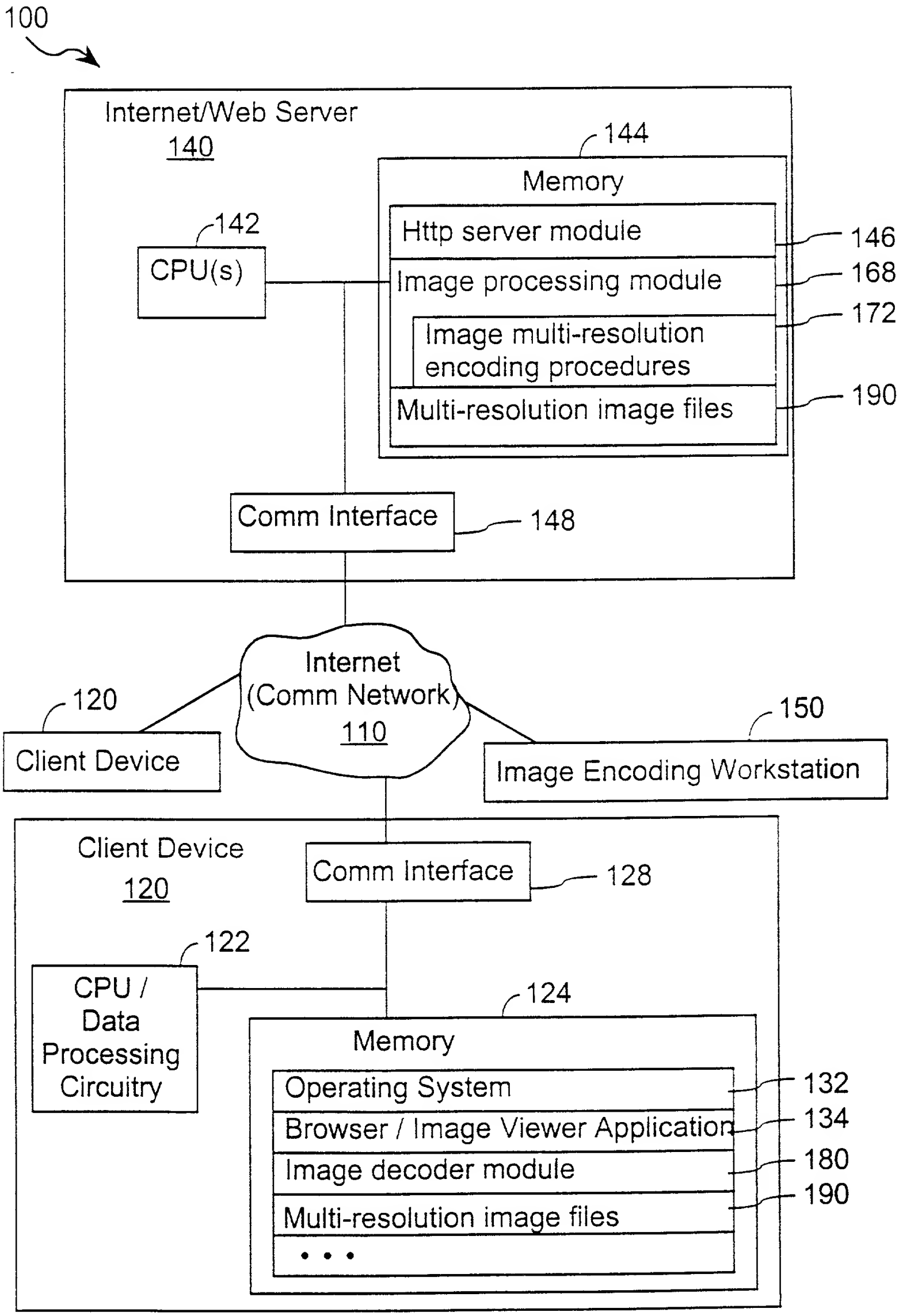

100
Internet/Web Server
140
144
Memory
142
CPU(s)
Http server module
146
Image processing module
168
Image multi-resolution encoding procedures
172
Multi-resolution image files
190
Comm Interface
148
Internet
(Comm Network)
110
120
Client Device
150
Image Encoding Workstation
Client Device
120
Comm Interface
128
122
CPU / Data Processing Circuitry
124
Memory
Operating System
132
Browser / Image Viewer Application
134
Image decoder module
180
Multi-resolution image files
190
• • •

FIG. 4

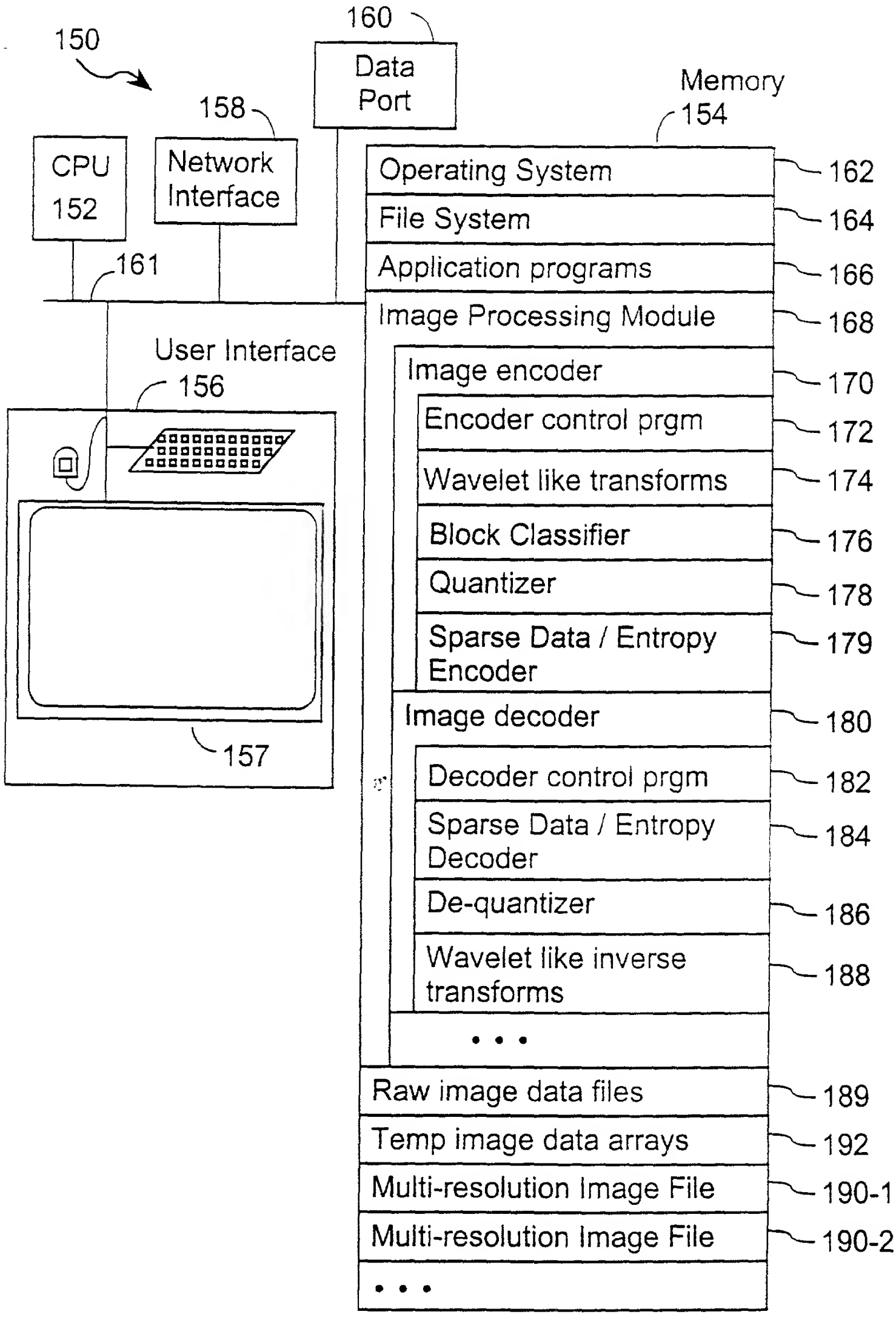

150
160
Data Port
158
Network Interface
Memory
154
CPU 152
161
Operating System
162
File System
164
Application programs
166
Image Processing Module
168
User Interface
156
Image encoder
170
Encoder control prgm
172
Wavelet like transforms
174
Block Classifier
176
Quantizer
178
Sparse Data / Entropy Encoder
179
Image decoder
180
Decoder control prgm
182
Sparse Data / Entropy Decoder
184
De-quantizer
186
Wavelet like inverse transforms
188
• • •
157
Raw image data files
189
Temp image data arrays
192
Multi-resolution Image File
190-1
Multi-resolution Image File
190-2
• • •

FIG. 5

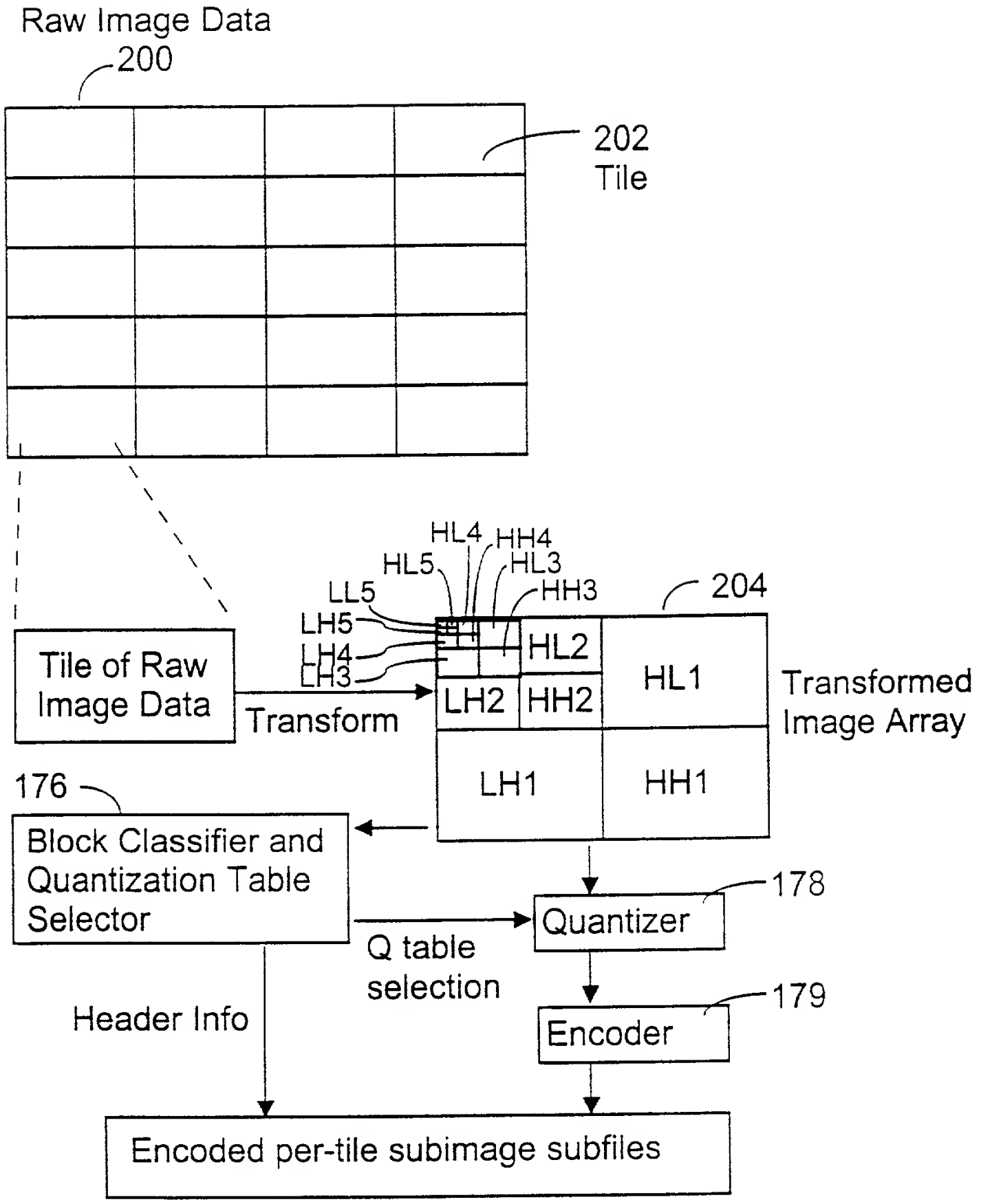

Raw Image Data
200
202
Tile
Tile of Raw Image Data
Transform
LL5
LH5
LH4
LH3
HL4
HH4
HL5
HL3
HH3
204
HL2
HL1
LH2
HH2
LH1
HH1
Transformed Image Array
176
Block Classifier and Quantization Table Selector
Q table selection
Quantizer
178
Header Info
Encoder
179
Encoded per-tile subimage subfiles

FIG. 6A

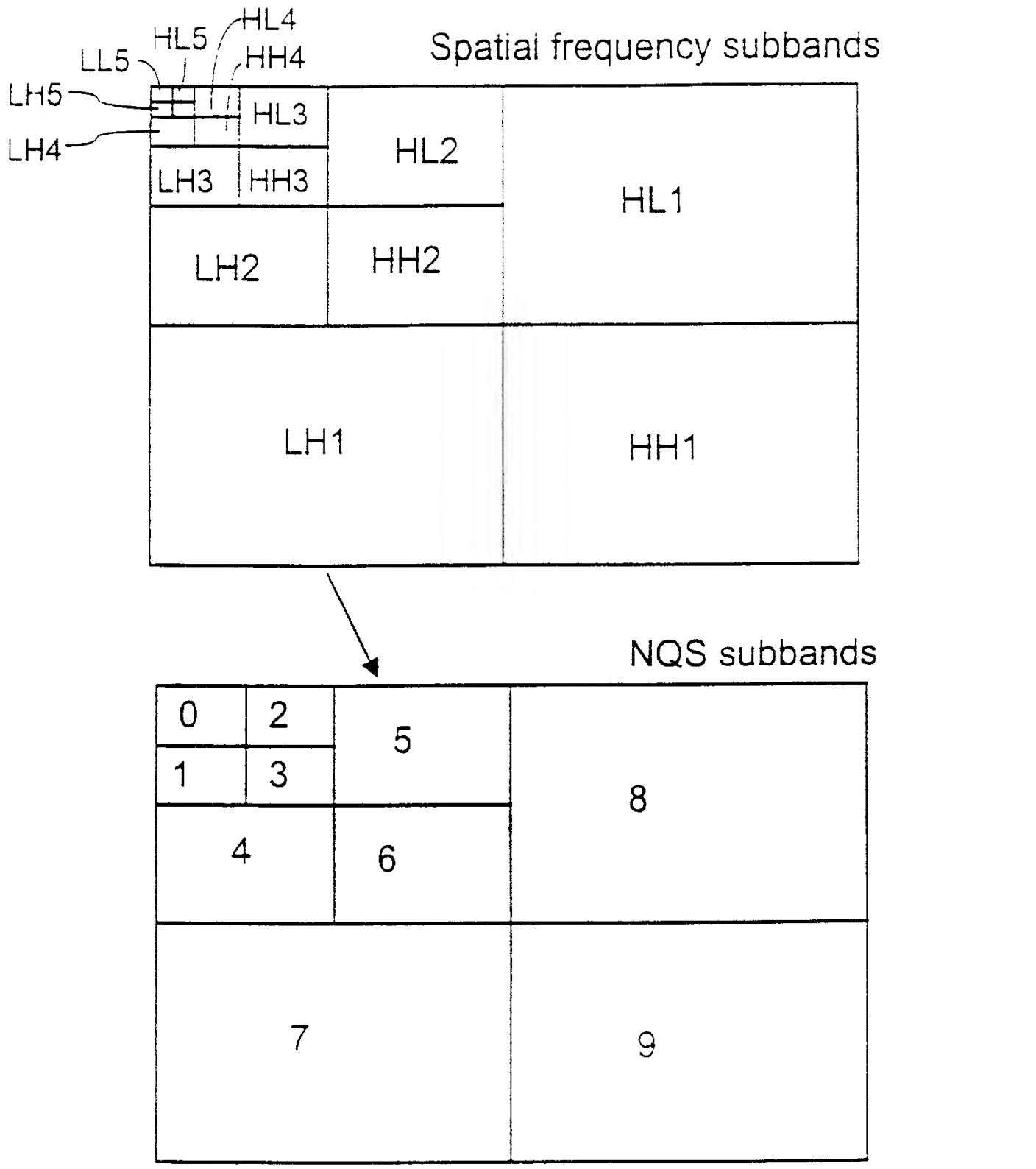


FIG. 6B

Figure 7

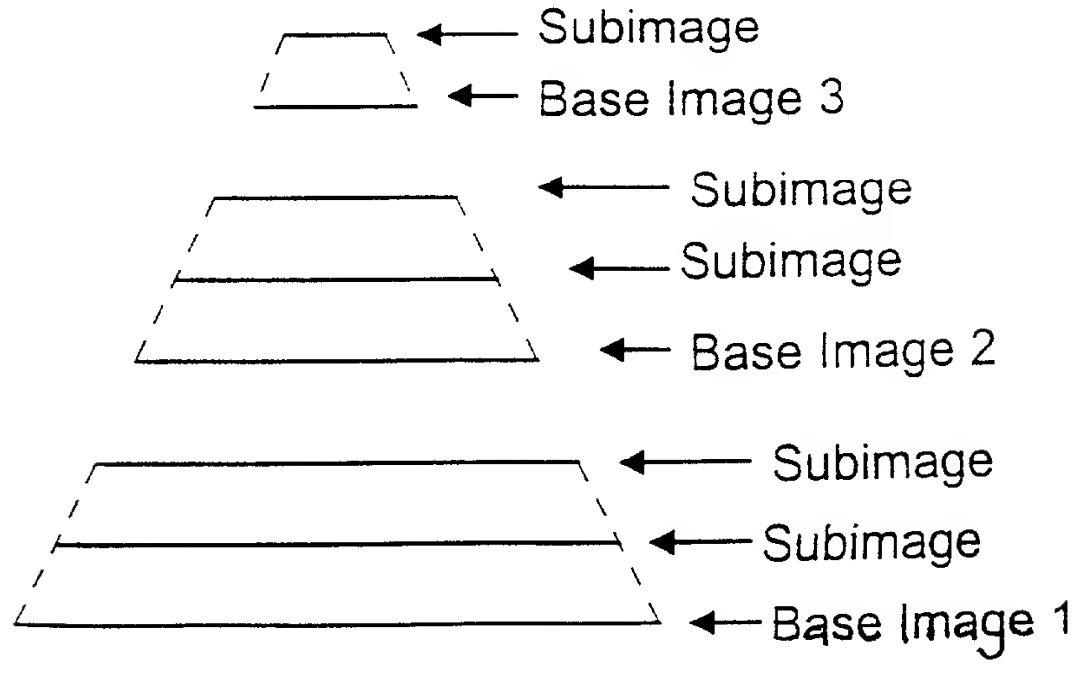


Figure 8A

Image File (Encoded Image Data Structure) 190-A

ID or URL of Image file in server;
Number of base images;
Information for each base image:
Image size: X, Y;
Cropped Image boundaries (for entire image and for subimages).
Offset pointer to base image in image file

Image Size: X, Y

Tile Size: X, Y

Color channel components

Transform filters used

Number of subbands (# of transform layers)

Number of bitstreams

Mapping of bitstreams to subimages

Information for each Bitstream:
offset pointer to Bitstream;
size of bitstream;
range of subbands included in bitstream;
# of color channels in bitstream;
range of bitplanes included in bitstream for each subband within the bitstream;
Table of offset pointers to each tile within the bitstream.
Q table ID for each tile.

Image File Header — 194

BaseImage 1 — 196

BaseImage 2

⋮

Link to embedded applet for decoding image file — 198

Java applet for decoding image file — 199

196

Base Image Header — 204

BitStream 1a — 206

BitStream 1b

BitStream 2a

⋮

Bitstream N

206

(optional) Bitstream Header — 209

Tile 0: Bitstream i — 208

Tile 1: Bitstream i — 208

⋮

Tile n: Bitstream i

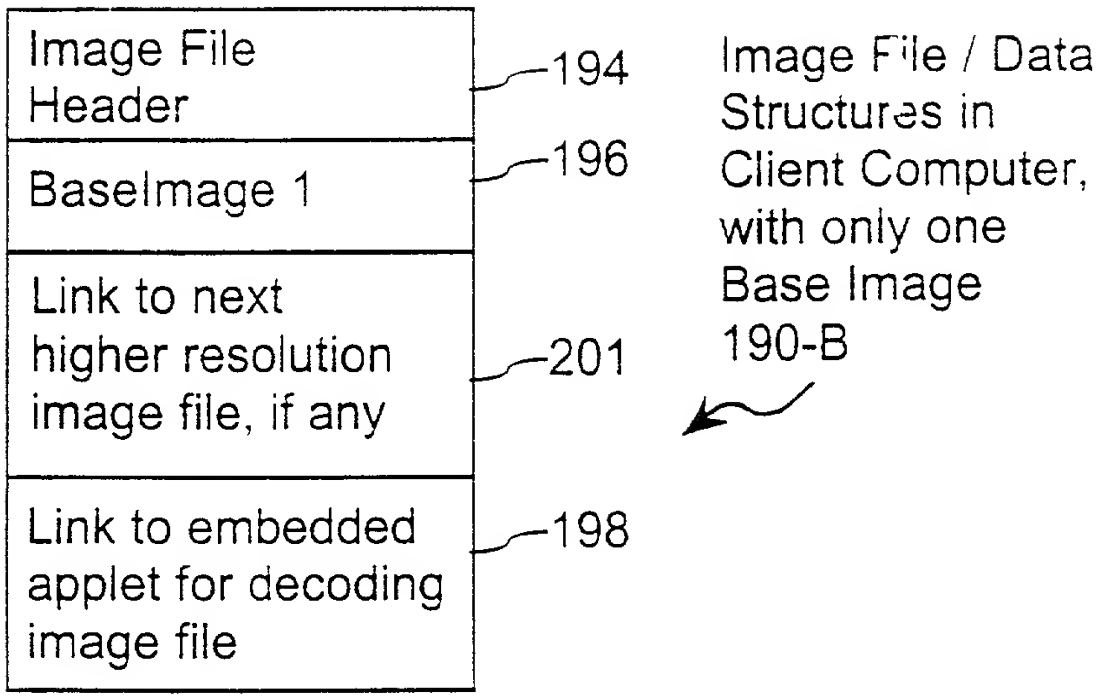


Image File
Header
194
BaseImage 1
196
Link to next
higher resolution
image file, if any
201
Link to embedded
applet for decoding
image file
198
Image File / Data
Structures in
Client Computer,
with only one
Base Image
190-B

FIG. 8B

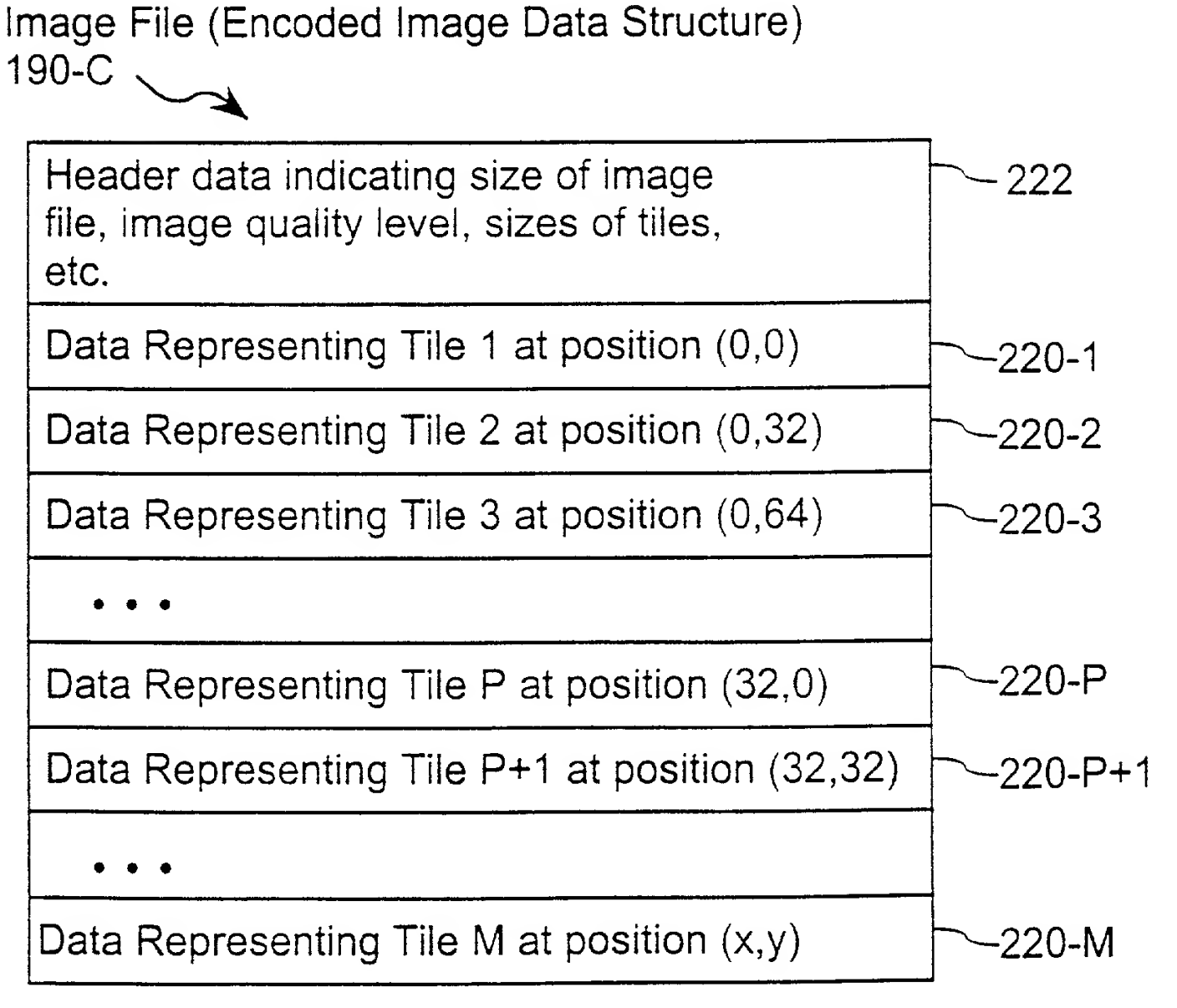


Image File (Encoded Image Data Structure)
190-C
Header data indicating size of image
file, image quality level, sizes of tiles,
etc.
222
Data Representing Tile 1 at position (0,0)
220-1
Data Representing Tile 2 at position (0,32)
220-2
Data Representing Tile 3 at position (0,64)
220-3
• • •
Data Representing Tile P at position (32,0)
220-P
Data Representing Tile P+1 at position (32,32)
220-P+1
• • •
Data Representing Tile M at position (x,y)
220-M

FIG. 8C

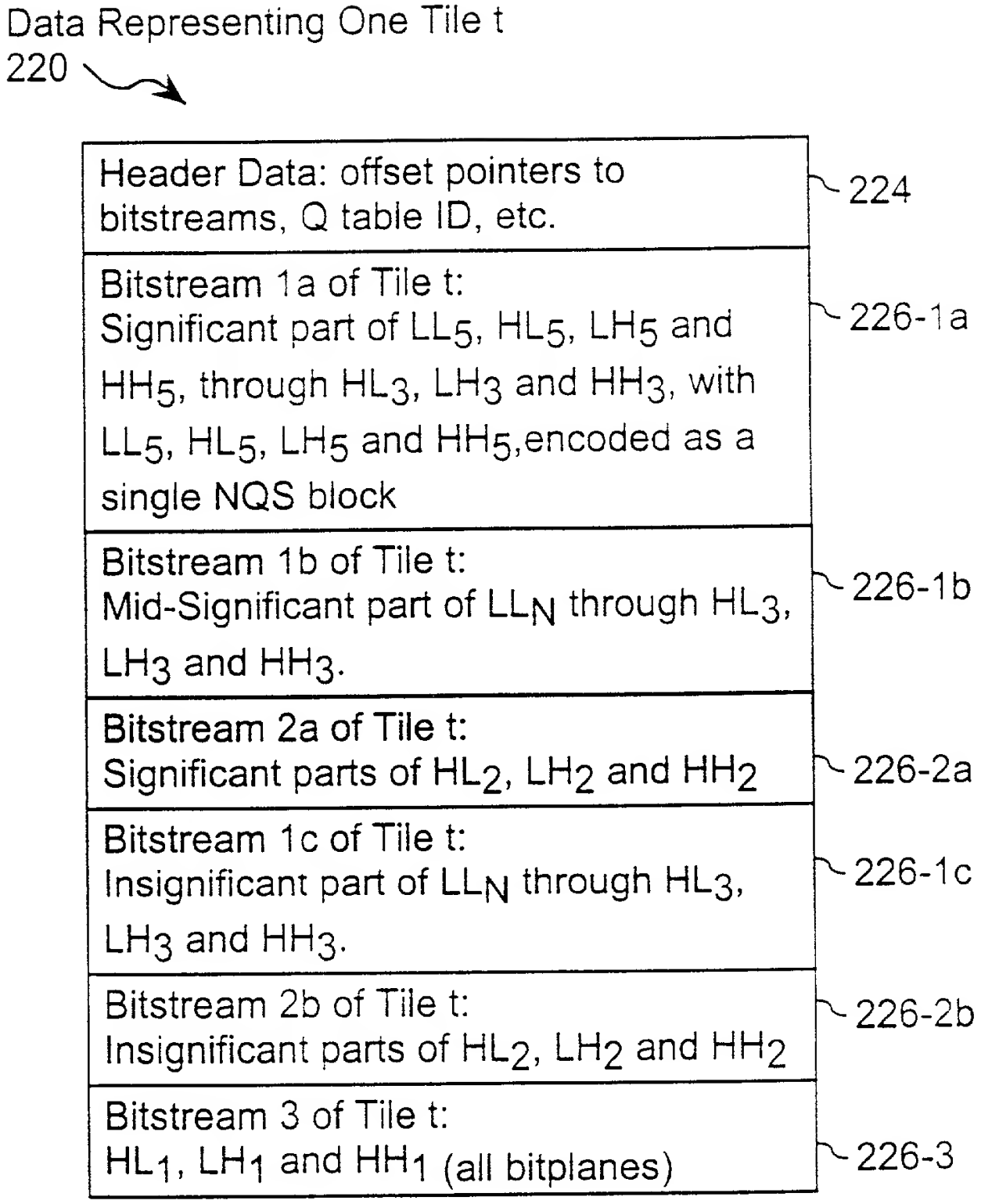

Data Representing One Tile t
220
Header Data: offset pointers to bitstreams, Q table ID, etc.
224
Bitstream 1a of Tile t: Significant part of LL_5, HL_5, LH_5 and HH_5, through HL_3, LH_3 and HH_3, with LL_5, HL_5, LH_5 and HH_5,encoded as a single NQS block
226-1a
Bitstream 1b of Tile t: Mid-Significant part of LL_N through HL_3, LH_3 and HH_3.
226-1b
Bitstream 2a of Tile t: Significant parts of HL_2, LH_2 and HH_2
226-2a
Bitstream 1c of Tile t: Insignificant part of LL_N through HL_3, LH_3 and HH_3.
226-1c
Bitstream 2b of Tile t: Insignificant parts of HL_2, LH_2 and HH_2
226-2b
Bitstream 3 of Tile t: HL_1, LH_1 and HH_1 (all bitplanes)
226-3

FIG. 8D

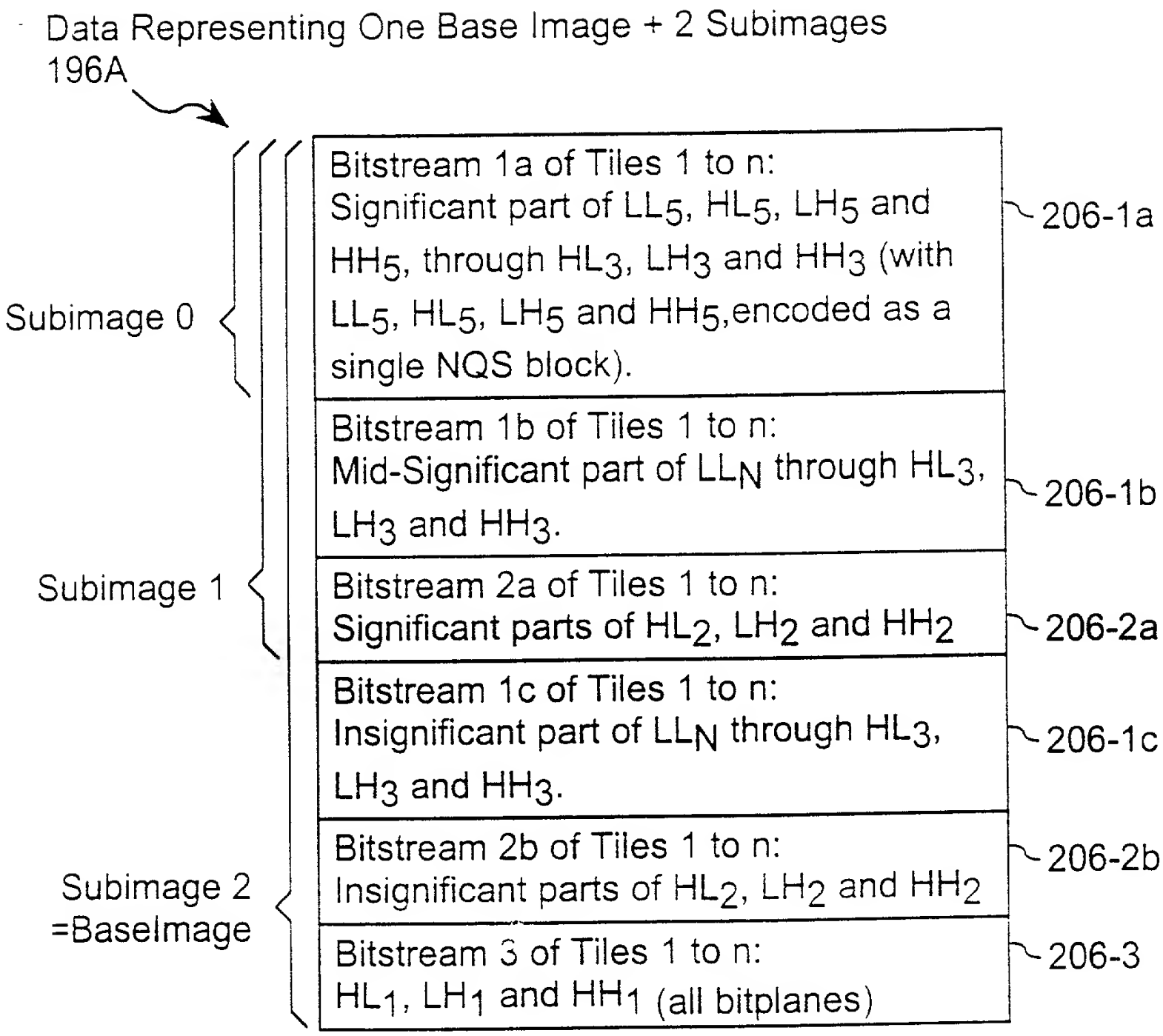

Data Representing One Base Image + 2 Subimages
196A
Subimage 0
Subimage 1
Subimage 2
=BaseImage
Bitstream 1a of Tiles 1 to n:
Significant part of LL5, HL5, LH5 and HH5, through HL3, LH3 and HH3 (with LL5, HL5, LH5 and HH5,encoded as a single NQS block).
206-1a
Bitstream 1b of Tiles 1 to n:
Mid-Significant part of LLN through HL3, LH3 and HH3.
206-1b
Bitstream 2a of Tiles 1 to n:
Significant parts of HL2, LH2 and HH2
206-2a
Bitstream 1c of Tiles 1 to n:
Insignificant part of LLN through HL3, LH3 and HH3.
206-1c
Bitstream 2b of Tiles 1 to n:
Insignificant parts of HL2, LH2 and HH2
206-2b
Bitstream 3 of Tiles 1 to n:
HL1, LH1 and HH1 (all bitplanes)
206-3

FIG. 8E

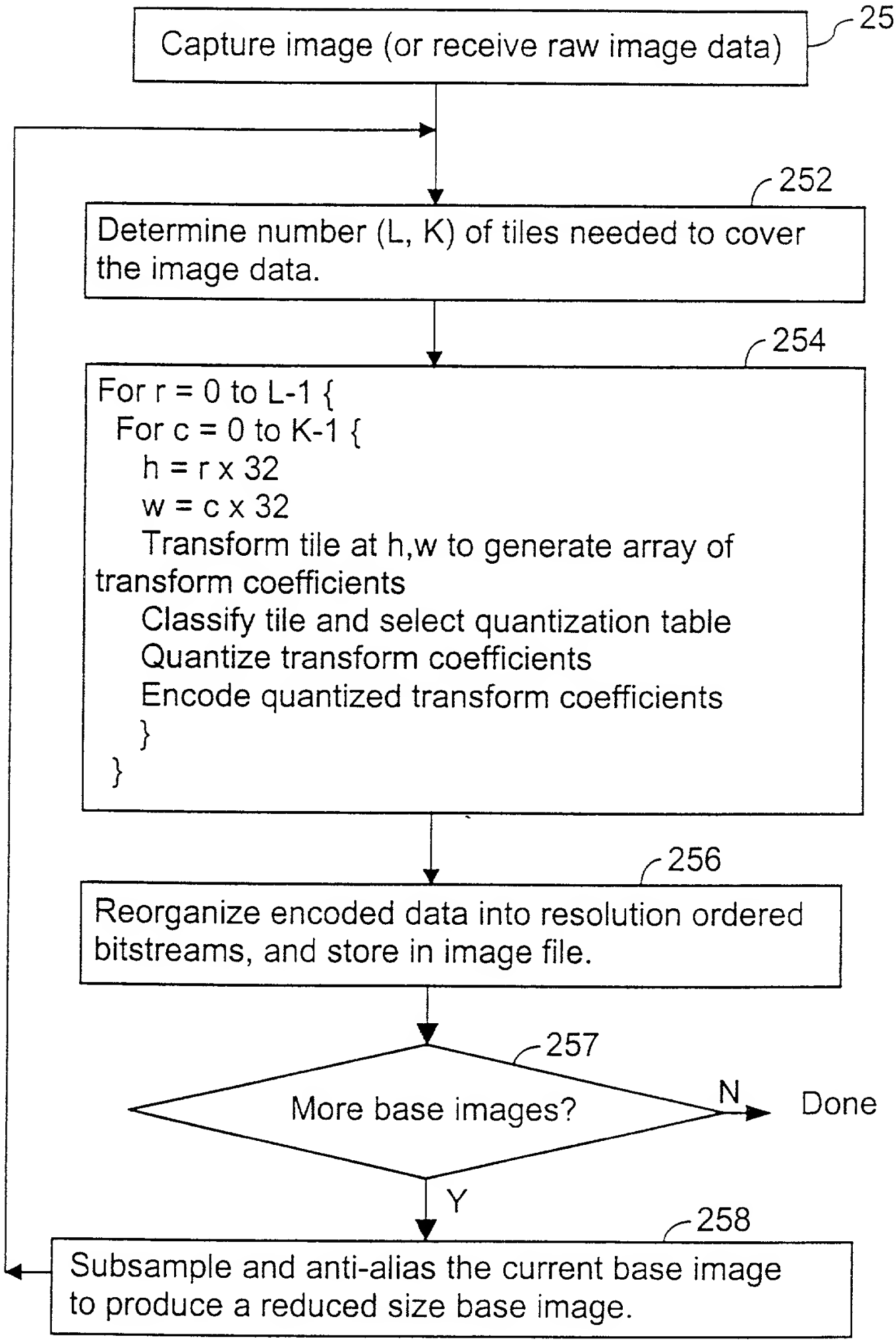

Capture image (or receive raw image data)
250
252
Determine number (L, K) of tiles needed to cover the image data.
254
For r = 0 to L-1 {
For c = 0 to K-1 {
h = r x 32
w = c x 32
Transform tile at h,w to generate array of transform coefficients
Classify tile and select quantization table
Quantize transform coefficients
Encode quantized transform coefficients
}
}
256
Reorganize encoded data into resolution ordered bitstreams, and store in image file.
257
More base images?
N
Done
Y
258
Subsample and anti-alias the current base image to produce a reduced size base image.

FIG. 9

Forward Transform

$[X_0, X_1, ..., X_{2n-1}]$

$[L_0, L_1, ..., L_{n-1}; H_0, H_1, ..., H_{n-1}]$

FIG. 10A

X_0	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
Y_0		Y_1		Y_2		Y_3		Y_4		Y_5		Y_6		Y_7	
L_0		L_1		L_2		L_3		L_4		L_5		L_6		L_7	
H_0		H_1		H_2		H_3		H_4		H_5		H_6		H_7	

FIG. 10B

Inverse Transform

$[L_0, L_1, ..., L_{n-1}; H_0, H_1, ..., H_{n-1}]$

$[X_0, X_1, ..., X_{2n-1}]$

FIG. 10C

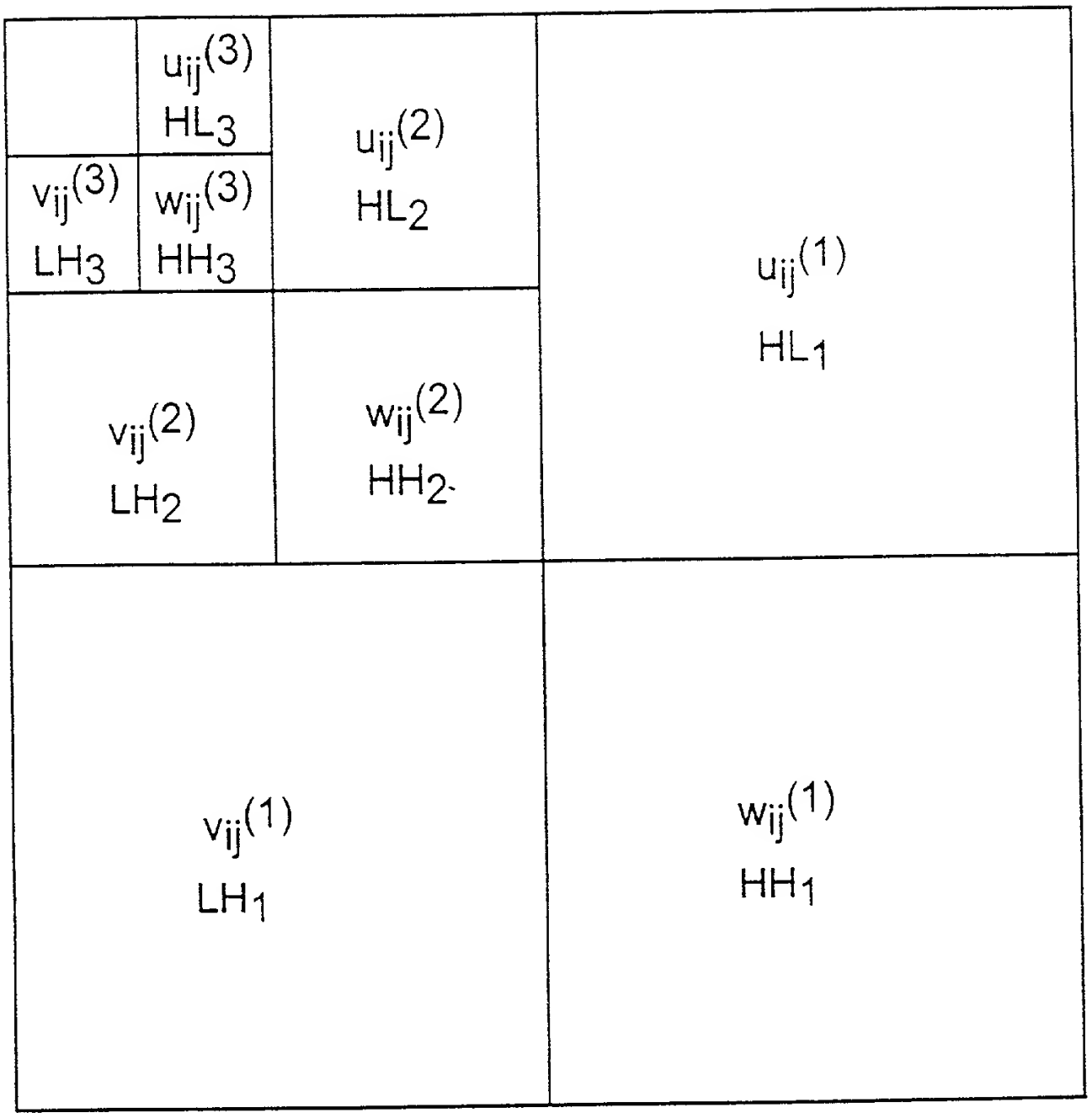

$u_{ij}^{(3)}$ HL_3
$u_{ij}^{(2)}$ HL_2
$u_{ij}^{(1)}$ HL_1
$v_{ij}^{(3)}$ LH_3
$w_{ij}^{(3)}$ HH_3
$v_{ij}^{(2)}$ LH_2
$w_{ij}^{(2)}$ HH_2
$v_{ij}^{(1)}$ LH_1
$w_{ij}^{(1)}$ HH_1

FIG. 11

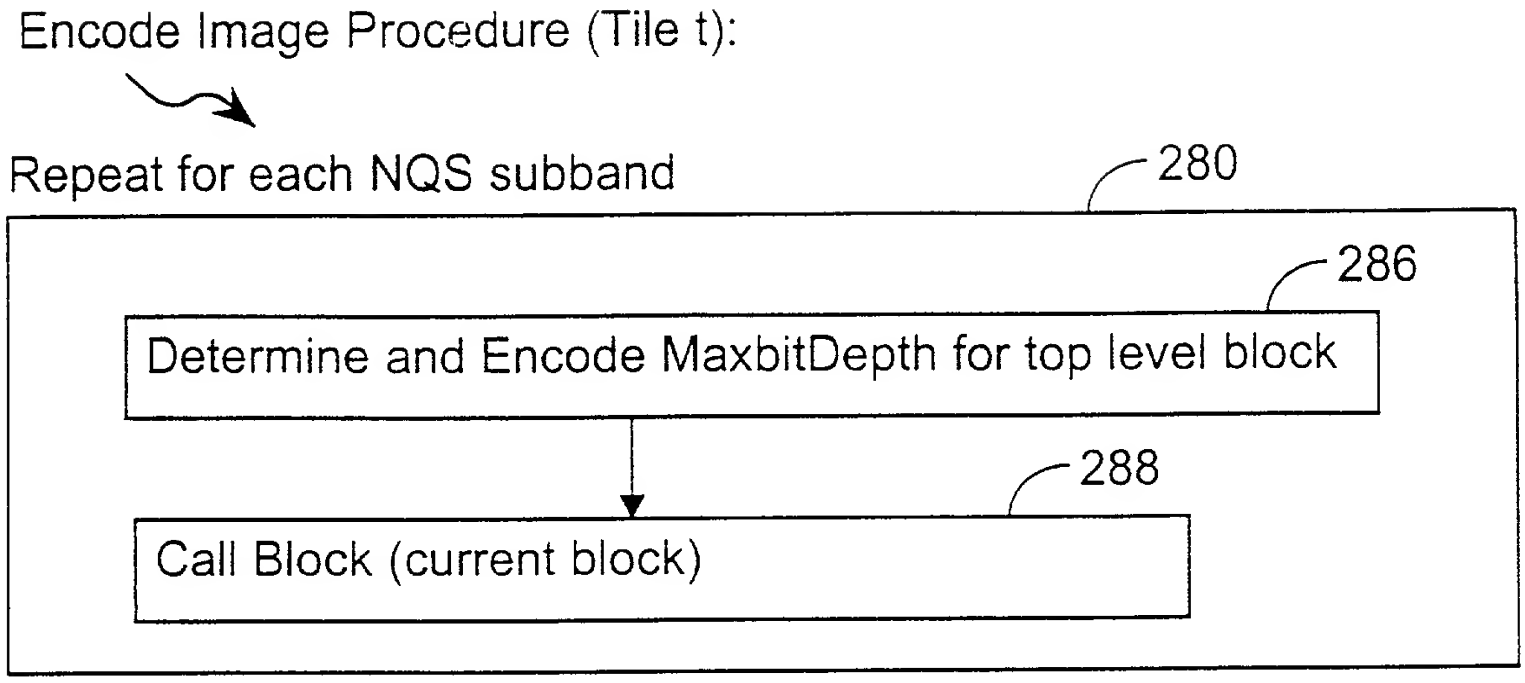
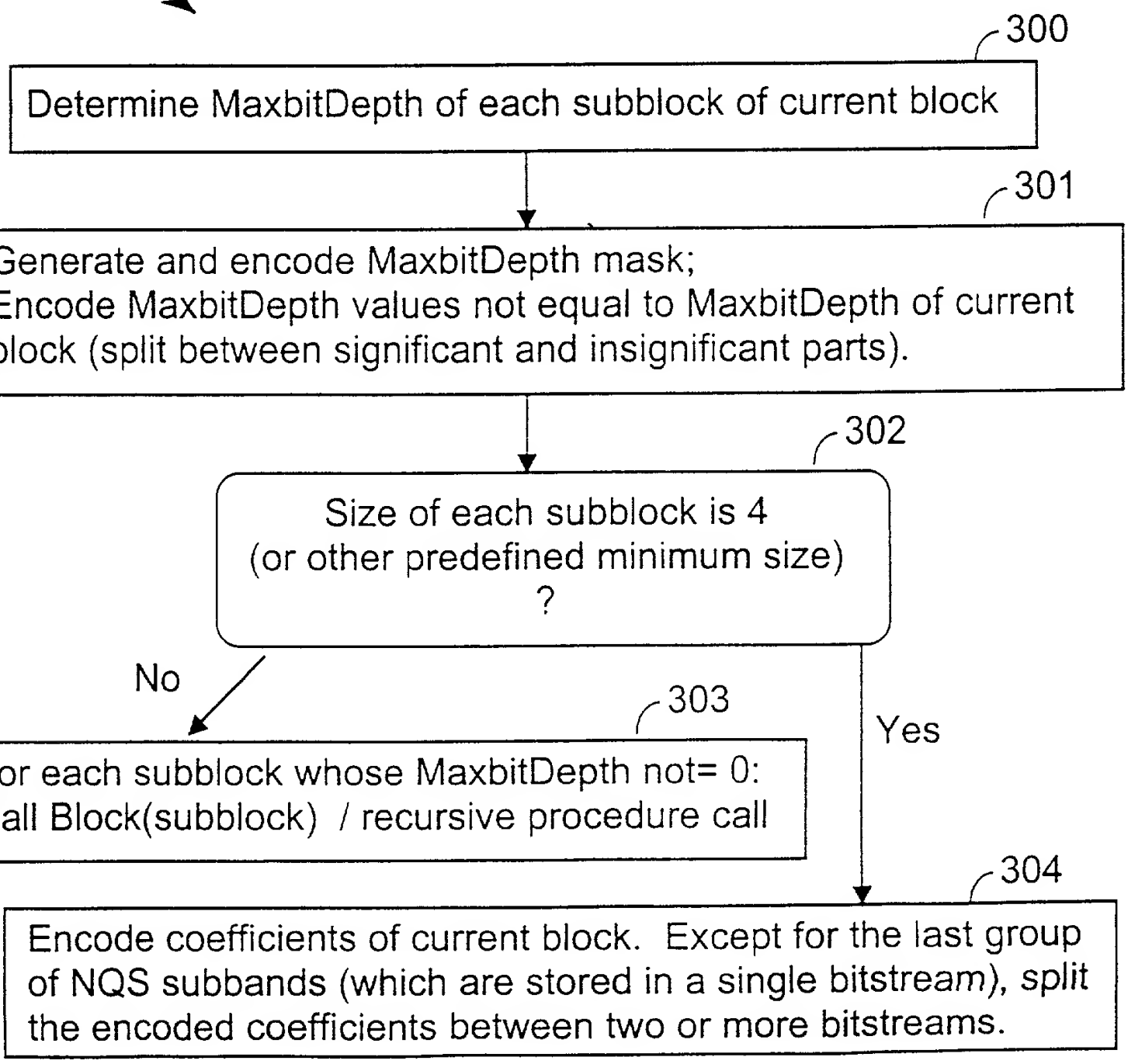


FIG. 13A

Fig 13B



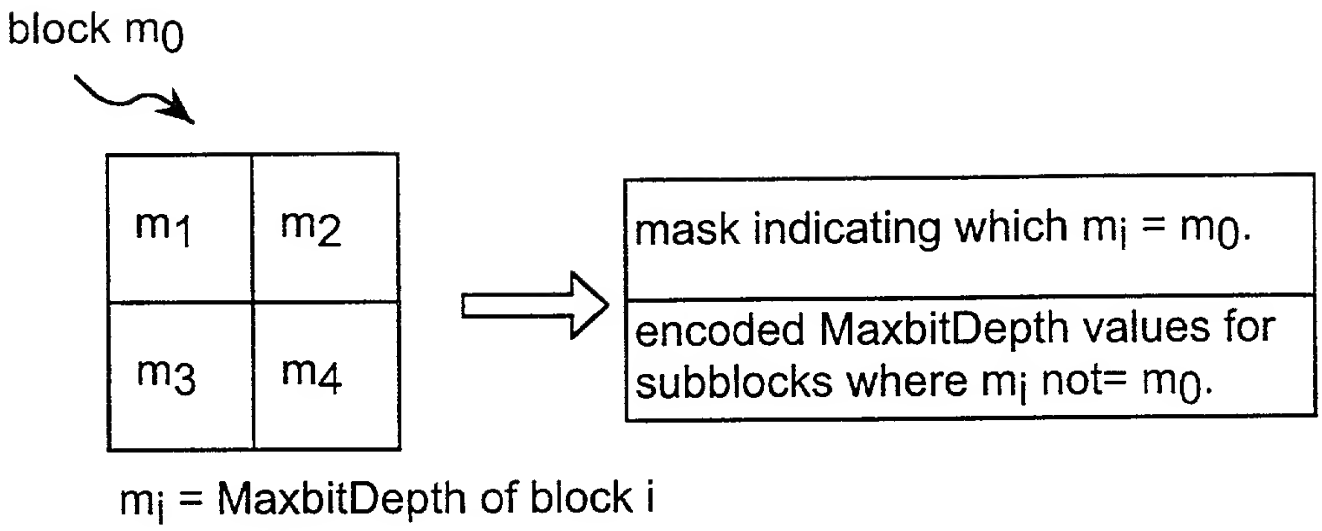


FIG. 14 A

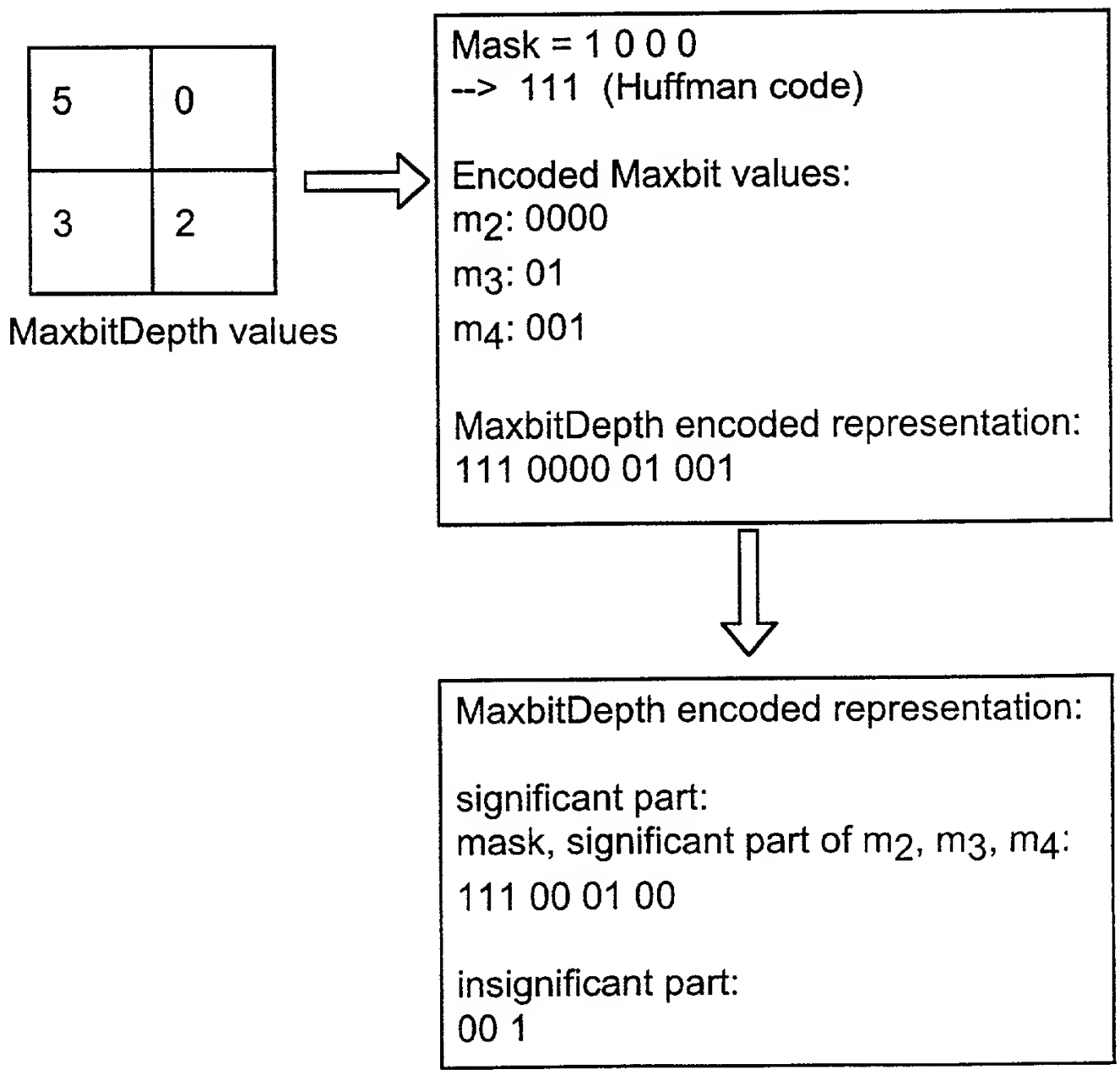


FIG. 14 B

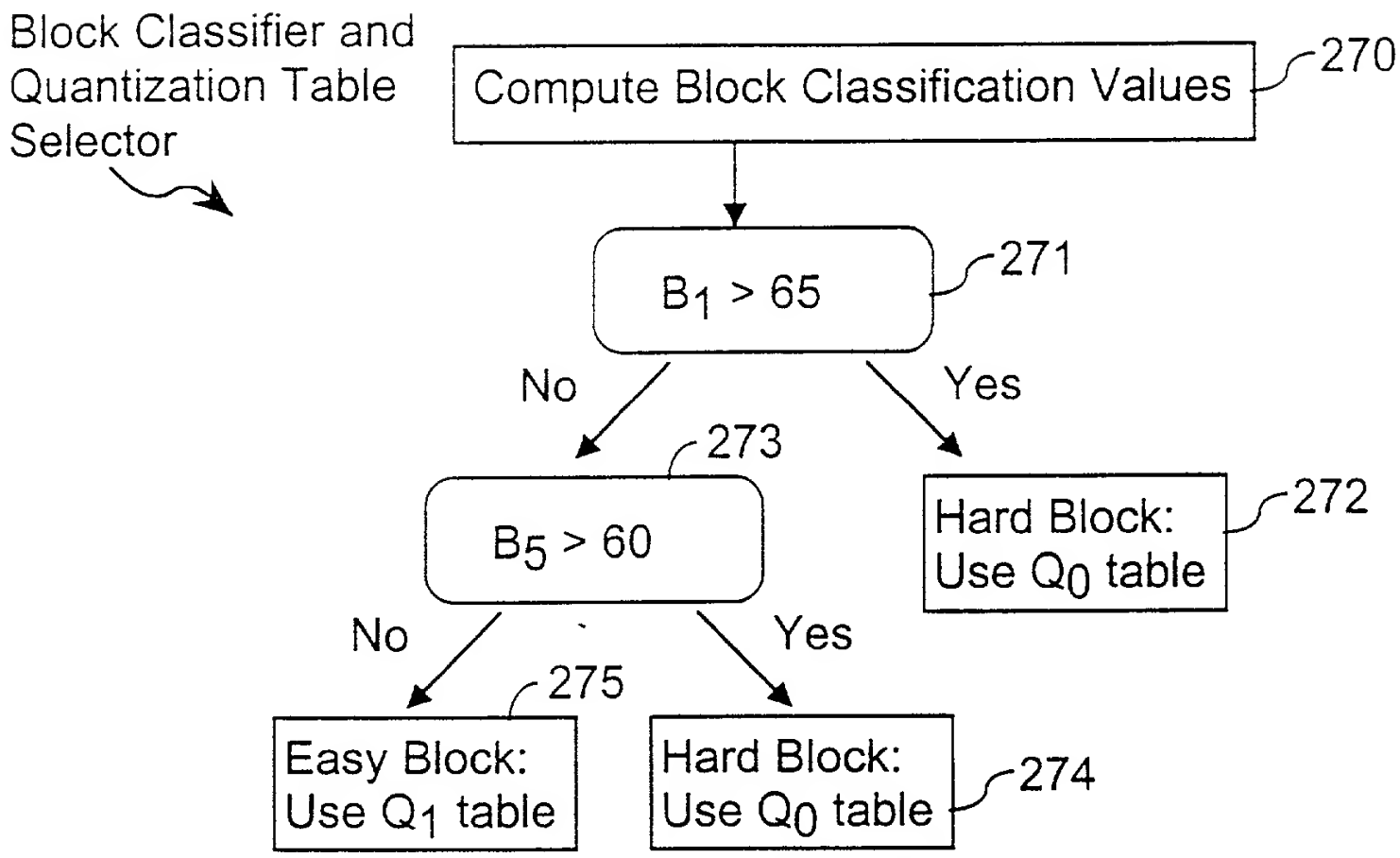


FIG. 12

Example

Encoding of Coefficients: 31, 0, -5, -2

significant part (threshold=3 bits):
POS 1, NEG

insignificant part:
111, 01, NEG 0

(MSB of each coefficient is known from MaxbitDepth values)

FIG. 14C

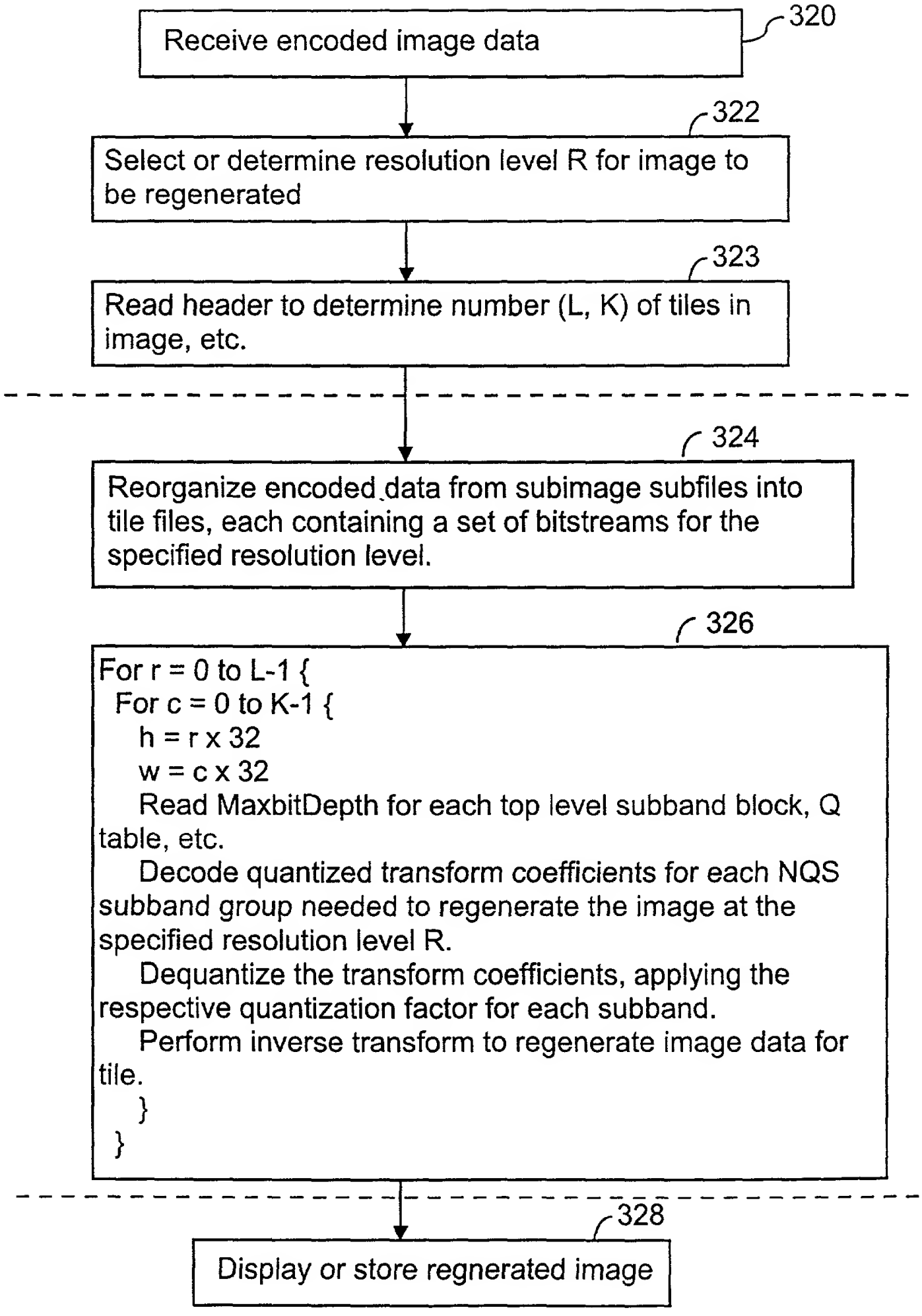

Receive encoded image data
320
Select or determine resolution level R for image to be regenerated
322
Read header to determine number (L, K) of tiles in image, etc.
323
Reorganize encoded data from subimage subfiles into tile files, each containing a set of bitstreams for the specified resolution level.
324
For r = 0 to L-1 {
For c = 0 to K-1 {
h = r x 32
w = c x 32
Read MaxbitDepth for each top level subband block, Q table, etc.
Decode quantized transform coefficients for each NQS subband group needed to regenerate the image at the specified resolution level R.
Dequantize the transform coefficients, applying the respective quantization factor for each subband.
Perform inverse transform to regenerate image data for tile.
}
}
326
Display or store regnerated image
328

FIG. 15

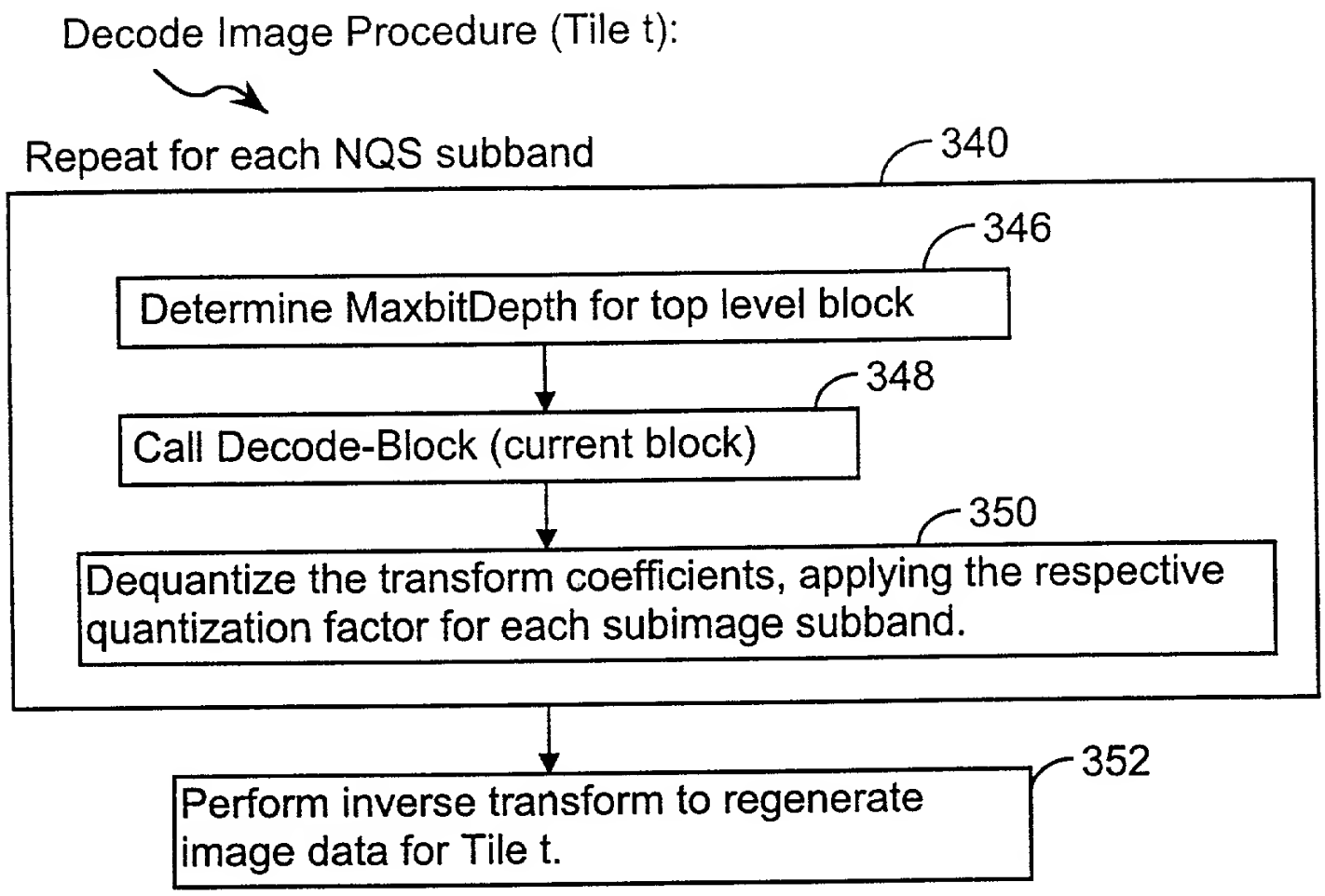


FIG. 16A

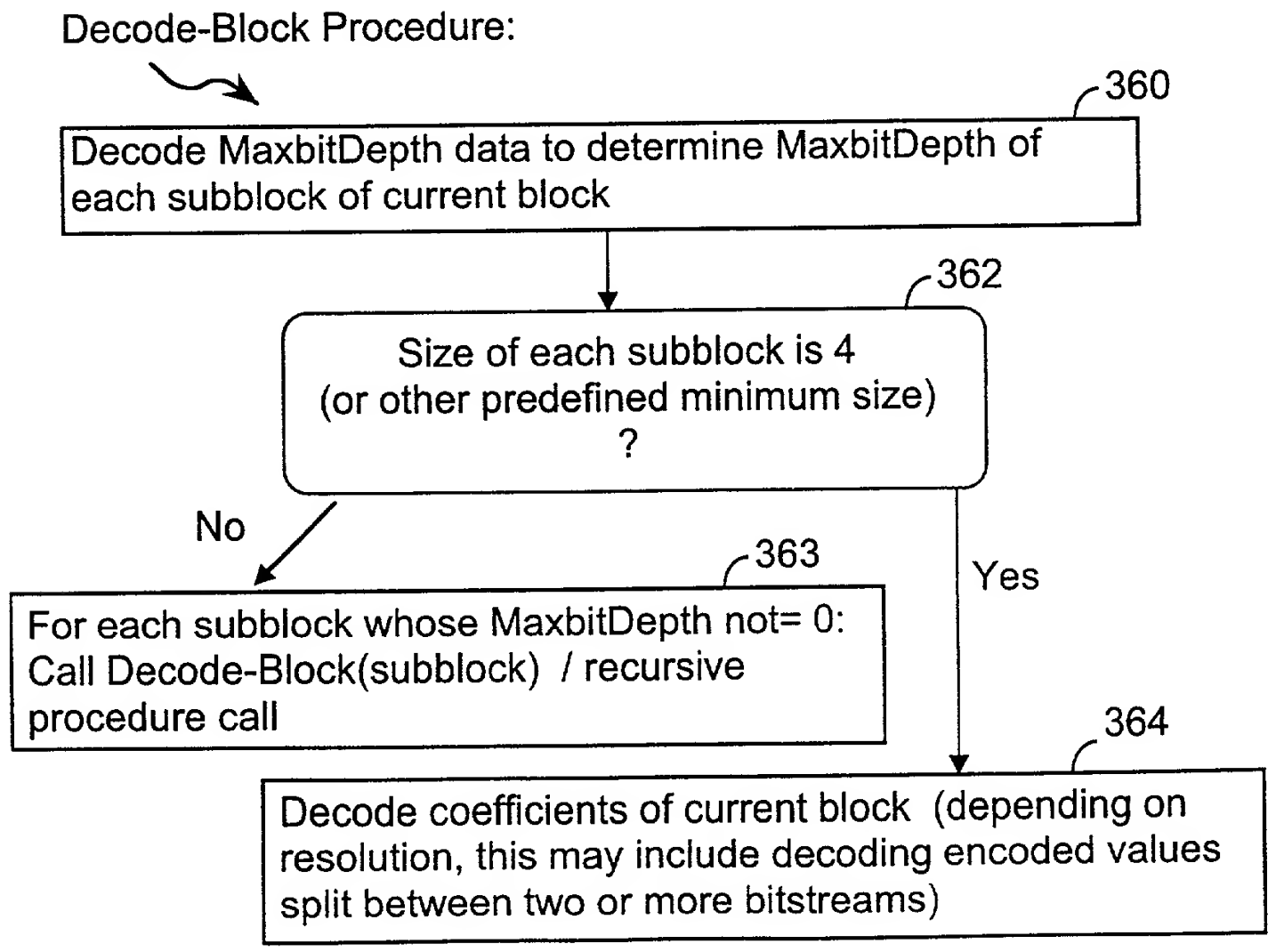


FIG. 16B

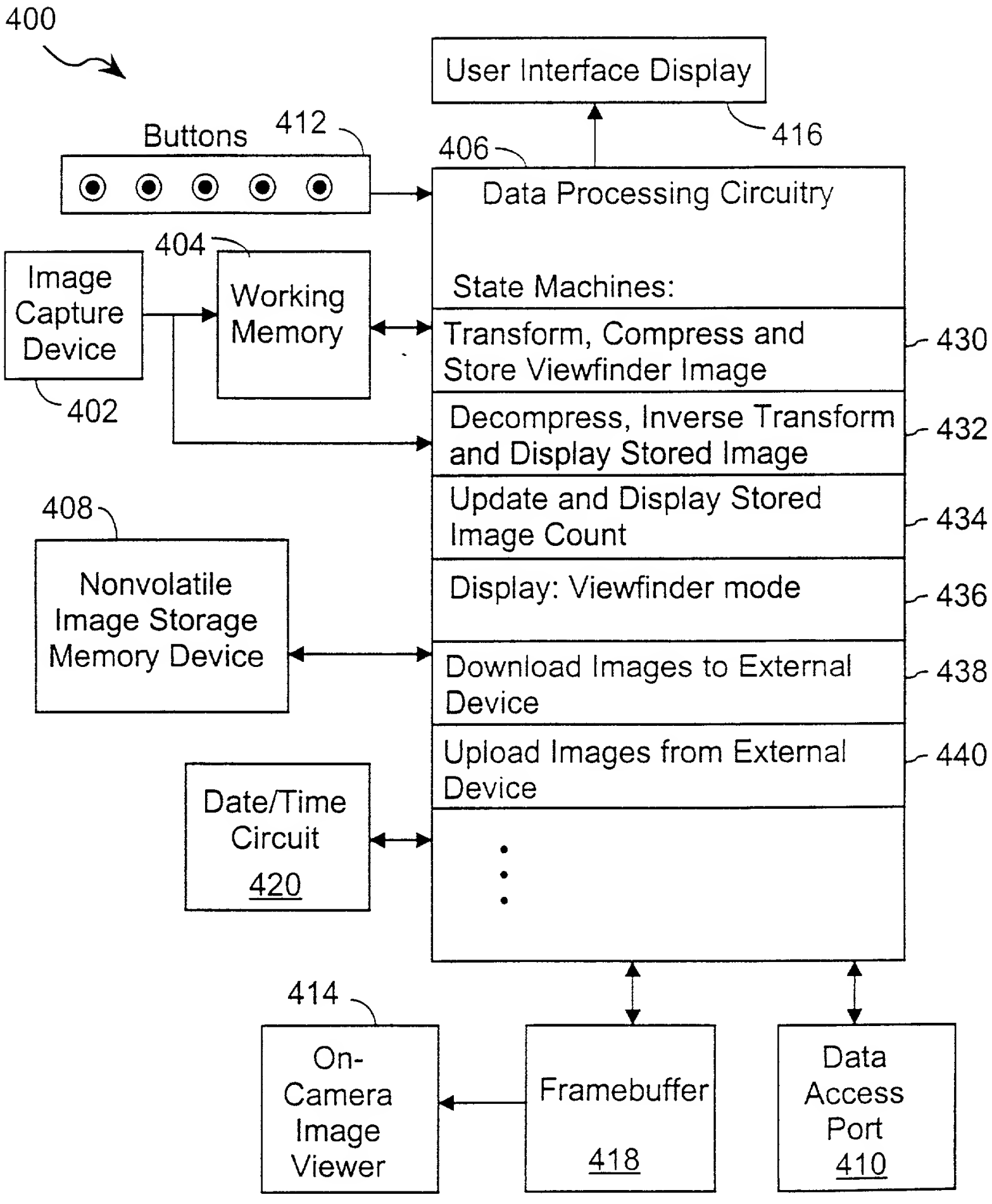

400
User Interface Display
416
Buttons
412
406
Data Processing Circuitry
State Machines:
404
Image Capture Device
Working Memory
402
Transform, Compress and Store Viewfinder Image
430
Decompress, Inverse Transform and Display Stored Image
432
Update and Display Stored Image Count
434
408
Nonvolatile Image Storage Memory Device
Display: Viewfinder mode
436
Download Images to External Device
438
Upload Images from External Device
440
Date/Time Circuit
420
414
On-Camera Image Viewer
Framebuffer
418
Data Access Port
410

FIG. 17

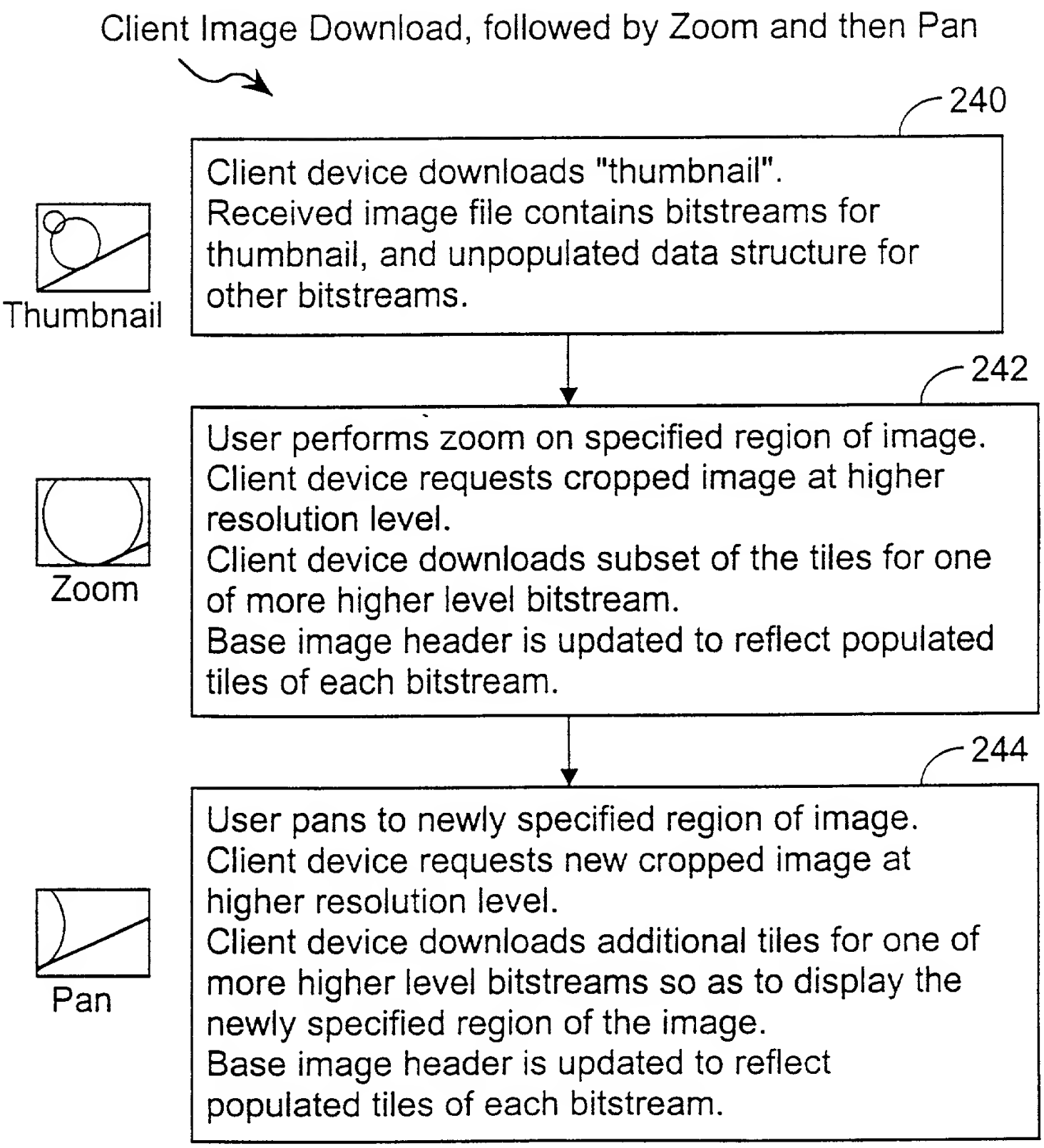

Client Image Download, followed by Zoom and then Pan
240
Client device downloads "thumbnail".
Received image file contains bitstreams for thumbnail, and unpopulated data structure for other bitstreams.
Thumbnail
242
User performs zoom on specified region of image.
Client device requests cropped image at higher resolution level.
Client device downloads subset of the tiles for one of more higher level bitstream.
Base image header is updated to reflect populated tiles of each bitstream.
Zoom
244
User pans to newly specified region of image.
Client device requests new cropped image at higher resolution level.
Client device downloads additional tiles for one of more higher level bitstreams so as to display the newly specified region of the image.
Base image header is updated to reflect populated tiles of each bitstream.
Pan

FIG. 18